Shrinkage of juvenile and mature wood of loblolly pine from three locations

Robert H. McAlister
Alexander Clark III

Abstract

Shrinkage of juvenile and mature wood was measured in loblolly pines from three Southwide Pine Seed Source Study plantings. The three seed sources were: Onslow County, N.C., Livingston Parish, La., and the local seed source. The sample planting sites were: the Georgia Coastal Plain, the Georgia Piedmont, and the Arkansas Upper Coastal Plain. Plantation location significantly affected longitudinal shrinkage of juvenile and mature wood, but geographic seed source did not.

Southern pine plantations produce wood with a high proportion of juvenile wood. Compared to mature wood, juvenile wood has lower specific gravity, shorter fibers, high fibril angle, thinner cell walls, less alpha cellulose, lower strength, lower stiffness, greater longitudinal shrinkage, and a tendency toward more reaction wood (compression wood) (5).

One-third of all southern pine stands are plantations, and plantations already provide more than half of the softwood timber in some locations. It is estimated that by the year 2000 the percentage of plantation-grown trees will increase to over two-thirds of the total harvest (7). The stems of these plantation-grown trees are 30 to 50 percent juvenile wood compared to 10 to 15 percent for stems from natural stands.

This study was part of a larger interdisciplinary study encompassing measures of site quality, climate, and environmental factors on parameters such as rate of growth, length of juvenility, percent latewood, specific gravity (SG), bark thickness, form factor of the stem, and the weight of the crown. Results of a companion study on modulus of elasticity and modulus of rupture have been published (4).

Objective

The objective of the study described here was to determine the effect of seed source and geographic location on the dimensional stability (primarily longitudinal shrinkage) of juvenile and mature wood of loblolly pine (*Pinus taeda* L.) plantations established in the Southwide Pine Seed Source Study.

Materials and procedures

Study material was taken from three plantations established under the Southwide Pine Seed Source Study (8). The original objective of that study was to determine the inherent geographic variation in the four major southern pine species. The three planting locations included in this study were: Dooly County, Ga. (Atlantic Coastal Plain with deep sandy loam soil); Spalding County, Ga. (Piedmont with heavy red clay soil); and Clark County, Ark. (Upper Coastal Plain with loamy sandy soil) (Fig. 1).

Each planting was established in a randomized complete-block design with four replications. Each replication of each seed source consisted of a square 121-tree-plot with 72 trees in border rows and 49 periodically measured interior trees. Spacing was 6 by 6 feet. Survival, height, and damage by diseases and insects were recorded on each plot after the 1st, 3rd, 5th, and 10th growing seasons. Diameter at breast height (d.b.h.) was recorded after the 10th growing season. Measurements and observations were made at 5-year intervals after the 10th year. The plots were

The authors are Forest Products Technologists, USDA Forest Serv., Southeastern Forest Expt. Sta., Forestry Sci. Lab., Green Street, Athens, GA 30602. This paper was presented at the 44th Annual Meeting, Forest Products Research Society, Salt Lake City, UT, June 24-27, 1990, and was received for publication in November 1991.

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thinned at age 15 to 70 ft.^{2} of basal area per acre. The study trees were harvested in 1988.

The dominant or codominant trees with the largest, average, and smallest d.b.h. from the original 49 measurement trees were selected from each plot. The d.b.h. and crown class were recorded before the trees were felled. Stump height, height to 7-, 4-, 3-, and 2-inch diameter outside bark (d.o.b.) tops, height to base of live crown, and total height were recorded for each tree.

Procedures

Specimens for measurement of dimensional stability were taken from a 20- to 30-inch-long stem section obtained from a relatively knot-free area of the stem immediately above breast height. This stem section was bandsawn down the pith and then sawn into 1-1/4-inch slabs. A nominal 1- by 1- by 12-inch juvenile wood specimen was sawn from the slab adjacent and parallel to the pith. The mature wood specimen was sawn from the same slab adjacent and parallel to the bark (Fig. 2). The specimens were left roughsawn.

Figure 1. — Location of study sites.

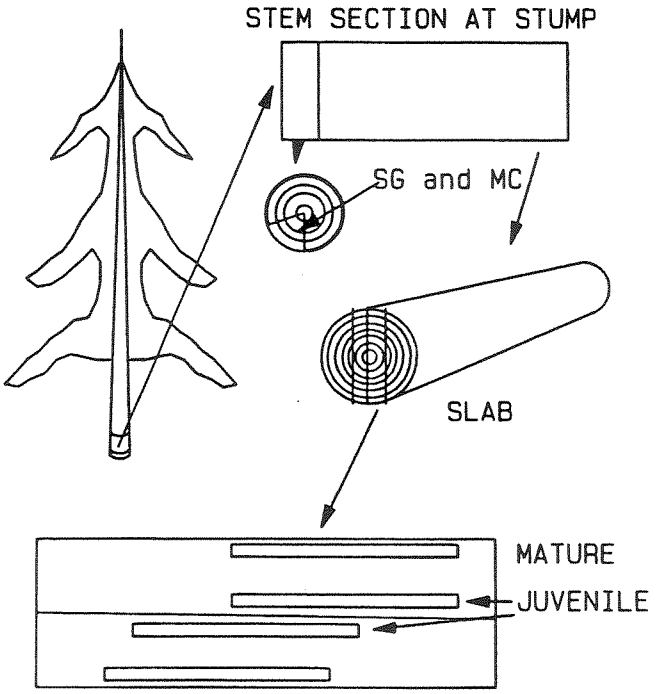

Figure 2. — Location of dimensional stability specimens in the tree stem.

TABLE 1. — *Shrinkage and specific gravity (SG) data for juvenile and mature loblolly pine wood by location.*

Location and type of wood	No. of trees	Average/(standard deviation) shrinkage of green to ovendried				
		Radial	Tangential	Longitudinal	Volumetric	SG
		(%)				
All						
Juvenile	144	3.90	4.68	0.47	7.41	0.40
		(1.28)	(1.14)	(0.30)	(3.81)	(0.04)
Mature	144	5.86	7.56	0.20	8.72	0.52
		(1.29)	(1.25)	(0.10)	(4.27)	(0.04)
Dooly County, Ga.						
Juvenile	48	4.43	4.82	0.42	7.97	0.40
		(1.30)	(1.01)	(0.23)	(3.63)	(0.04)
Mature	48	6.86	8.30	0.19	10.95	0.56
		(1.05)	(1.33)	(0.05)	(3.44)	(0.04)
Spalding County, Ga.						
Juvenile	48	3.59	4.33	0.57	7.38	0.40
		(1.44)	(1.35)	(0.38)	(3.93)	(0.04)
Mature	48	5.09	6.91	0.26	8.96	0.51
		(1.09)	(1.06)	(0.12)	(5.16)	(0.04)
Clark County, Ark.						
Juvenile	48	3.68	4.88	0.42	6.88	0.40
		(0.92)	(0.95)	(0.26)	(3.87)	(0.03)
Mature	48	5.64	7.47	0.16	6.27	0.51
		(1.03)	(0.95)	(0.09)	(2.44)	(0.03)

TABLE 2. — *Analysis of variance for radial (RAD), tangential (TAN), longtudinal (LON), and volumetric shrinkage (VOL), and specific gravity (SG) assuming location and seed source are fixed effects (F-values).*

Source	Estimated error mean square	Degrees of freedom	Juvenile wood					Mature wood				
			Shrinkage					Shrinkage				
			RAD	TAN	LON	VOL	SG	RAD	TAN	LON	VOL	SG
Location (L)	B(L)	2	2.17	2.04	5.67*[a]	0.64	3.03	9.46**[b]	17.01**	9.56**	6.67**	10.40**
Block(Loc) B(L)	B+S(L)	8	1.87	2.80*	0.71	0.63	0.56	2.38	0.58	1.64	1.66	1.09
Seed source (S)	B+S(L)	2	0.40	0.16	0.41	1.32	2.41	1.59	1.46	3.54	0.73	1.66
L×S	B×S(L)	4	2.46	4.99**	1.33	0.68	0.49	1.08	0.68	0.97	1.06	0.99
Block×S(L)	Error	16	0.77	0.73	1.37	1.56	2.08*	1.17	1.13	0.76	0.99	1.20
Error		75										

[a] * - Significant at the 0.05 level of probability.
[b] ** - Significant at the 0.01 level of probability.

Testing

The green dimensional stability specimens were marked for a 10-inch span on the pith and bark sides, and shallow 1/8-inch-diameter holes were drilled at the marks. The actual distance between the holes was measured with a linear comparator (3). This measurement and the midpoint radial and tangential dimensions of each specimen were recorded to the nearest 0.001 inch. The specimen weight to the nearest 0.1 g was also recorded.

The specimens were then brought to constant weight in a controlled environment with 12 percent equilibrium moisture content. The dimensions and weight for each specimen were again recorded. The samples were then ovendried and the measurements and weights again recorded. Radial, tangential, longitudinal, and volumetric shrinkage as well as moisture content and SG were calculated and the results exported to a PC-SAS (6) data set for statistical analysis using the GLM procedure.

Results and discussion

As expected, longitudinal shrinkage was generally higher in juvenile wood than in mature wood, and SG was lower (Table 1).

Trees from the Dooly County site had an average d.b.h. of 8.5 inches, significantly less than the average of 11.1 and 11.6 inches at the Spalding and Clark sites, respectively. The Dooly planting had significantly higher stand density than the Spalding or Clark plantings. This increased competition resulted in trees with smaller diameters in the Dooly planting. However, we attribute the significantly higher SGs from the Dooly samples primarily to other factors. Dooly County received less spring moisture but the same summer moisture as Spalding County and more summer moisture than Clark County.[1] The trees from Dooly probably converted from earlywood to latewood production earlier in the growing season but continued to produce latewood longer because of sufficient summer moisture and a longer growing season (1). Thus, the annual rings grown there had a higher percentage of latewood compared to the Spalding or Clark County locations.

The SG of the juvenile wood was quite uniform among sites, averaging 0.40 compared to 0.52 for the mature wood. The mature wood from the Dooly site had a significantly higher average SG than mature wood from the other study sites.

Results of statistical analysis of differences in shrinkage and SG of juvenile and mature wood are presented in Table 2. There were no statistically significant differences in juvenile wood for radial, tangential, or volumetric shrinkage or in SG due to study location or seed source. Longitudinal shrinkage in juvenile wood was significantly higher in samples from the Spalding site. There was no statistically significant difference between the longitudinal shrinkage of the Dooly and Clark sites. For mature wood, location was a statistically significant factor for all study variables. The Dooly site had higher SG and higher radial and tangential shrinkage than the Spalding or Clark sites. Longitudinal shrinkage in mature wood averaged about one-third of that in juvenile wood.

One factor that reduces the utility of juvenile wood in pine is its tendency toward excessive longitudinal shrinkage. Not all juvenile wood shrinks excessively. Longitudinal shrinkage is closely associated with fibril angle, which is difficult and time consuming to measure. We were not able to find any easily measured property related to longitudinal shrinkage. Some of the juvenile wood samples in this study actually increased in length after drying. This phenomenon has been observed in other studies (2) and may be related to growth stresses.

Summary and conclusions

Planting location was a statistically significant factor in the longitudinal shrinkage of juvenile wood. For mature wood, location was a statistically significant factor for radial, tangential, longitudinal, and volumetric shrinkage as well as SG. Geographic seed source was not a factor in dimensional stability of either juvenile or mature wood.

Juvenile wood was quite different than mature wood in dimensional stability parallel to the grain. Not all juvenile wood shows excessive longitudinal shrink-

[1] United States Dept. of Commerce, National Weather Serv. Monthly rainfall data for field weather station nearest study location.

age. There appears to be no easily measured physical property that is well correlated with longitudinal shrinkage of either juvenile or mature wood.

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